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(54) **REAMER WITH IMPROVED HYDRAULICS FOR USE IN A WELLBORE**

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(57) **ABSTRACT**

A reamer bit for use in earth boring operations comprising a body, mounting elements on the bit body having rolling cutters, and nozzles configured to emit a cleaning spray that is angled with respect to the well bottom. The cleaning spray may be angled up to about 20° with respect to the well bottom. The reamer may further include a pilot bit on a drill pipe extending downward from the reamer body.

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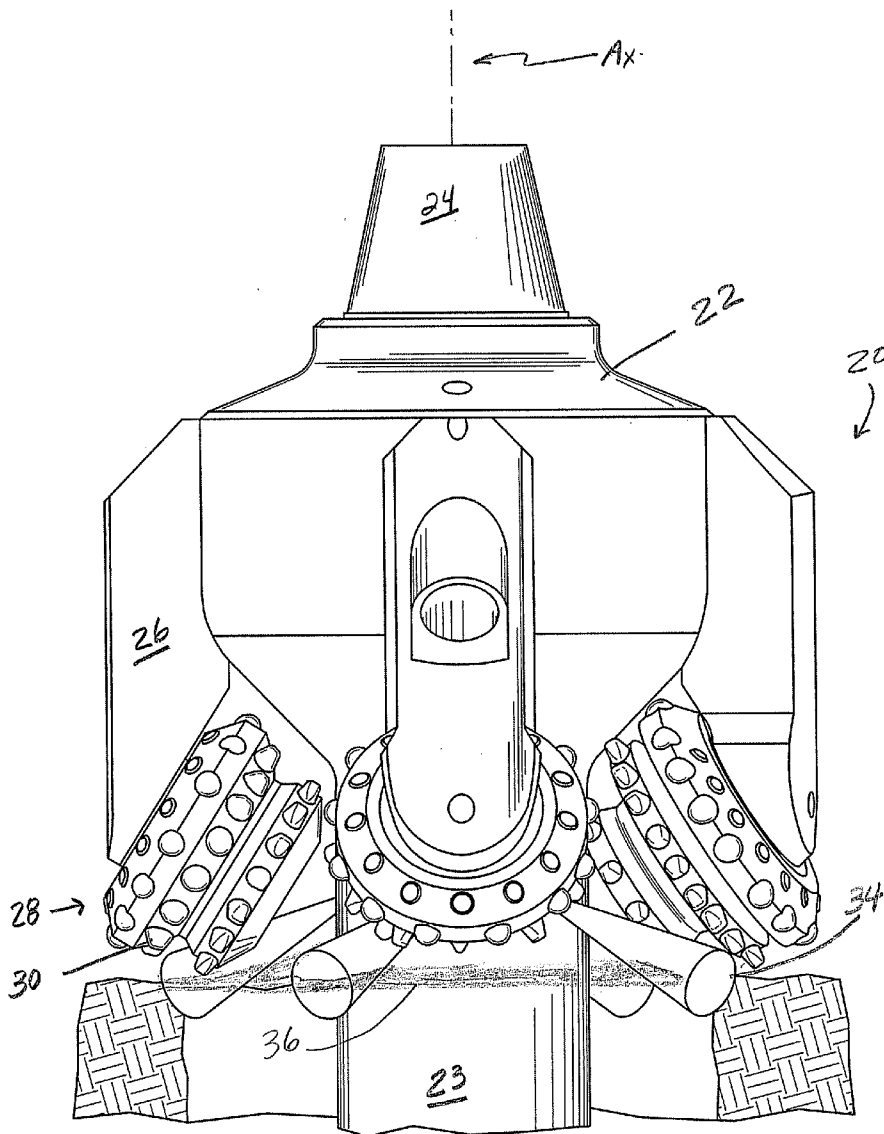


Fig. 1

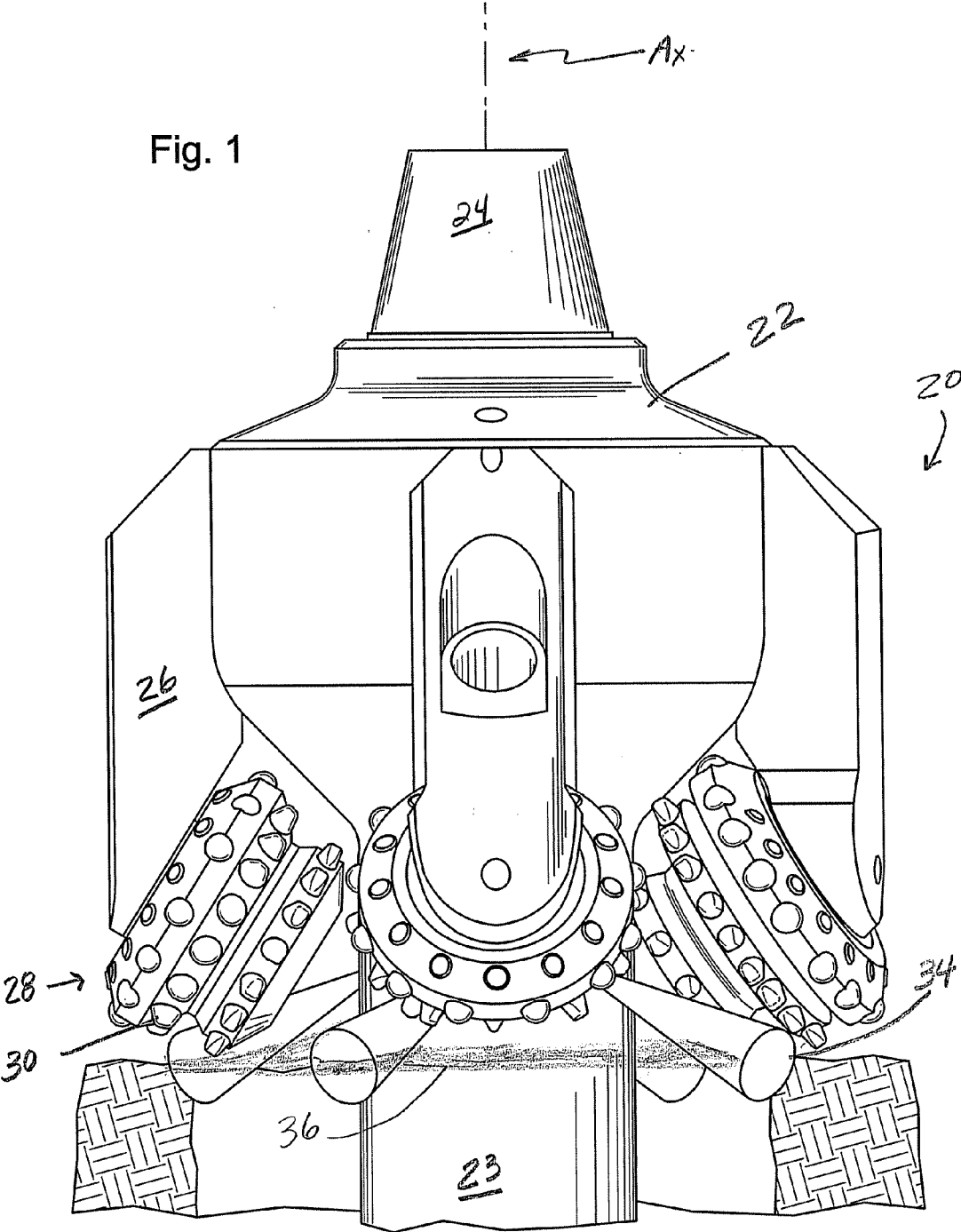


Fig. 2

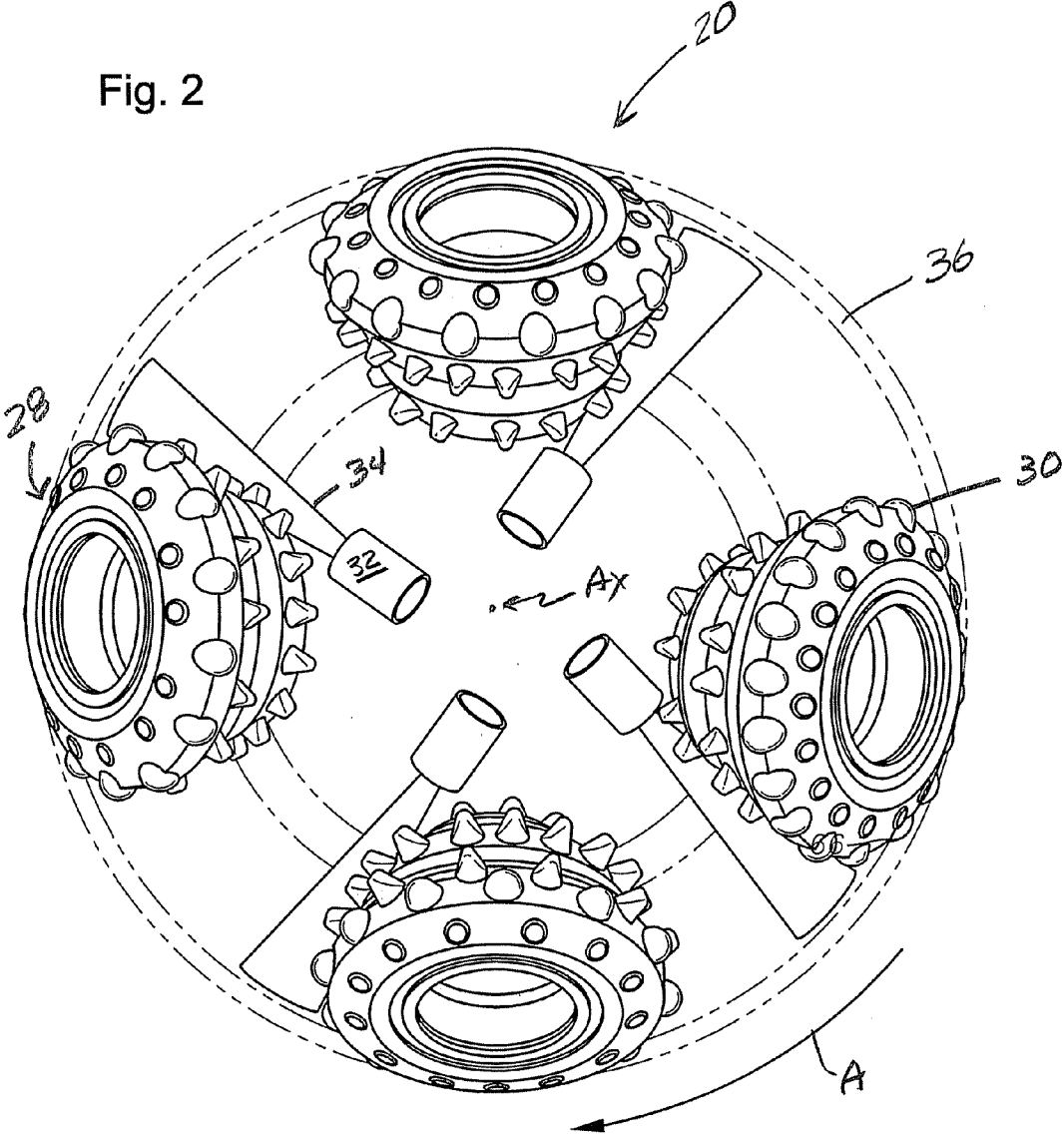


Fig. 3

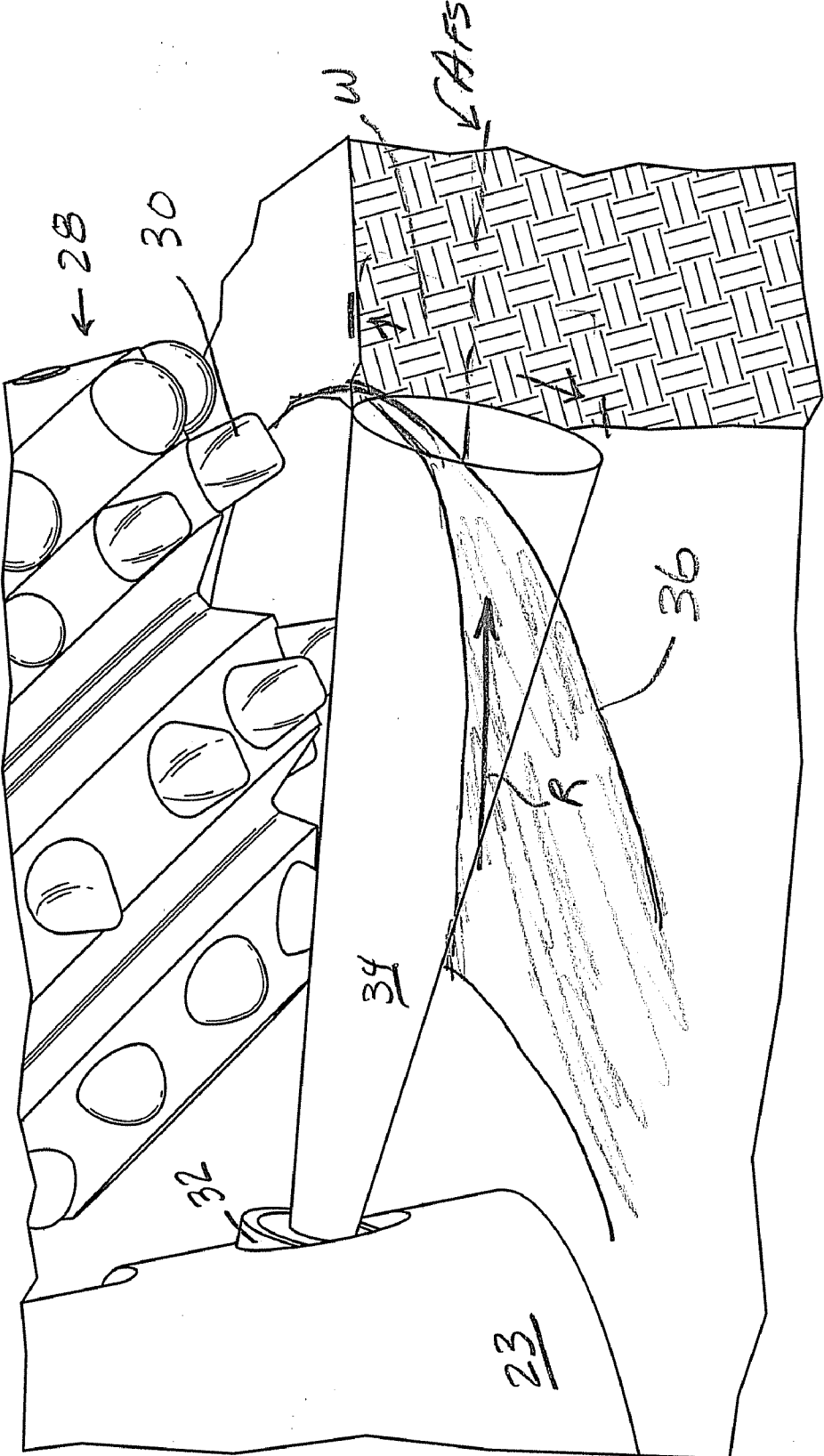
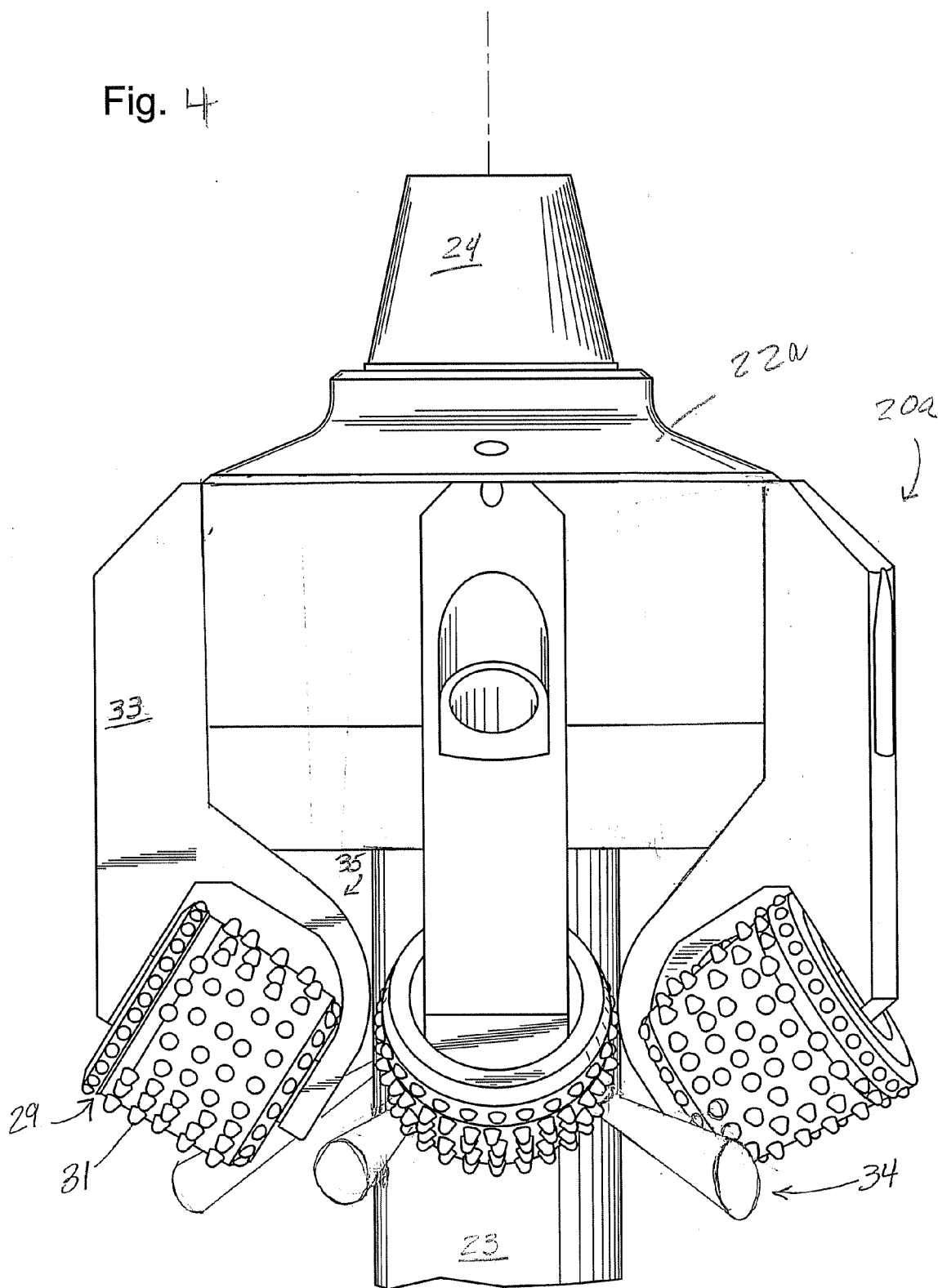


Fig. 4



REAMER WITH IMPROVED HYDRAULICS FOR USE IN A WELLBORE

RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of co-pending U.S. Provisional Application Ser. No. 61/016, 222, filed Dec. 21, 2007, the full disclosure of which is hereby incorporated by reference herein.

BACKGROUND

[0002] 1. Field of Invention

[0003] This disclosure relates to earth boring reamer bits, and particularly to reamer bits configured to discharge fluids at a low impingement angle to the reamer bit cutting surface.

[0004] 2. Description of Prior Art

[0005] Drill bits used in drilling of subterranean well bores typically comprise drag bits and roller cone bits. Roller cone bits typically comprise a body having legs extending downward and a head bearing extending from the leg towards the axis of the bit body. Frusto-conically shaped roller cones are rotatably mounted on each of these journals and have inserts on the outer surface of these cones. As the bit rotates, the cones rotate to cause the cutting elements to disintegrate the earth formation.

[0006] In some situations a pilot reamer drilling system is employed where two or more bits are combined on a single drill string at different vertical positions. The lower bit of the pilot reamer drilling system, which is commonly referred to as a pilot bit, creates a pilot hole. The upper bit, which follows the lower bit in the drilling process, enlarges the hole diameter over that created by the pilot bit. The bit enlarging the hole diameter is referred to as a reamer bit. Typically the pilot bit comprises a conventional earth boring bit, i.e. either a roller cone bit or a drag bit. The reamer bit usually employs rolling cutters as cutting members modified for attachment to the reamer bit body. Pilot reamer drilling systems are used to drill large diameter boreholes that require enhanced stabilization.

[0007] Drilling fluid for dispersing drilled up material and cooling the cutting elements may be injected at the cutting surfaces through nozzles. The injected fluid forms jet streams that typically are conically shaped and directed downward from the bit body. The fluid is typically injected as a high velocity jet to clean debris from drill bit cutting element thereby enhancing drilling. The dislodged particles are carried up through the borehole annulus to the surface for disposal.

SUMMARY OF INVENTION

[0008] The disclosure herein includes a reamer bit for downhole earth boring operations comprising a reamer body having an axis, mounting elements depending from the body, cutters rotatably mounted on each mounting element, and a nozzle configured to form a fluid spray at an angle away from the body axis. The cutter includes cutting elements configured to cuttingly engage a wellbore bottom surface. In one embodiment, the fluid spray is directed to the cutting surface in advance of the cutting elements. The fluid spray may impinge the cutting surface in a substantially shallow angle of from about 3° up to about 20° with respect to the cutting surface. The reamer bit can further comprise a drill shaft extending from the body lower end and a pilot bit affixed to the drill shaft terminal end. The pilot bit may be a roller cone

bit or a drag bit. The reamer bit is rotatable and the nozzle is configurable to direct a fluid spray in the direction of the reamer bit rotation.

BRIEF DESCRIPTION OF DRAWINGS

[0009] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0010] FIG. 1 is a side view of a reamer bit body with roller cone bits and hydraulic spray exiting the body.

[0011] FIG. 2 is an overhead view of roller cone and nozzle portions of a reamer bit illustrating fluid spray pattern exiting the nozzles.

[0012] FIG. 3 is a side perspective view of a fluid spray exiting a reamer bit body.

[0013] FIG. 4 depicts in a side view a reamer bit body with rolling cutters and hydraulic spray exiting the body.

[0014] While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

[0015] The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

[0016] It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

[0017] FIG. 1 provides in a side view an example of a reamer 20 comprising a generally cylindrical body 22 having mounting elements for attaching rolling cutters to the body 22. In FIG. 1, the mounting elements are bit legs 26 affixed to the body 22 outer lateral periphery. The bit legs 26, which may be welded into pockets formed on the outer surface of the bit body 22 extend downward and generally parallel with the body axis A. Each bit leg 26 comprises a shaft (not shown) extending from the bit body 26 and angled in a generally downward direction in towards the axis A. In the embodiment of FIG. 1, the rolling cutters comprise cones 28 that are rotatably mounted on each shaft and have rows of inserts 30 formed in a generally circumferential arrangement on the cone 28 outer surface. The inserts 30 also referred to as cutting elements or teeth may be integrally formed, such as by machining, or later attached after forming the cone 28 and affixed by an interference fit, welding, and/or brazing. For use

in earth boring operations, a connector **24** is provided on the upper portion of the housing **22** having threads (not shown) formed for coupling with an associated drill string. As is known, the drill string provides both downward force and rotatable force for drilling action within an associated formation.

[0018] Optionally, a shaft **23** may be included with the reamer **20** for connection to a pilot bit (not shown). Associated pilot bits with a reamer may be used for situation where an enhanced diameter well bore is desired or to increase the stability of the drilling operations. The reamer bit **20** is further equipped with nozzles **32** configured to emit a fluid spray **34** in a direction away from the body axis A and towards the cutting surface **36** engagable by the cones **28**. By being directed “away” from the body axis A the fluid spray **34** effectively sweeps across the cutting surface **36**. In contrast, a fluid spray directed largely downward impinges perpendicular the borehole bottom cutting surface covering a smaller area. Additionally, fluid spray **34** embodiments include a jet, where the jet can possess sufficient energy to remove formation in addition to circulating material excavated by the bit **20**.

[0019] FIG. 2 illustrates selected components of the reamer bit **20**. Shown in FIG. 2 are the cones **28** and their path of cutting a well bore bottom over the associated cutting surface **36**. Nozzles **32**, shown radially inward from the cones **28**, are configured to direct a fluid spray **34** onto the cutting surface **36** in advance of the cones **28**. The purposes of this disclosure, “in advance” refers generally to the expected path the cones **28** traverse on the cutting surface **36** while the cones are being rotated. The “in advance” region includes the cutting surface adjacent a cone **28** that upon any cone rotation will engage that surface; this region extends along the cutting surface **36** up to where the next adjacent cone **28** is contacting the cutting surface **36**. Arrow A illustrates the rotational direction of the reamer bit **20** within the borehole and along the cutting surface **36**. Thus as shown in FIG. 2, the sprays **34** contact the in advance region proximate to their associated cones **28**. Accordingly, in this embodiment directing the fluid spray **34** on the cutting surface **36** in advance of the cones provides a cleaning effect by removing any cuttings or other debris away from the projected path of an associated cutting cone **28**. The scope of this disclosure is not limited to bits having cleaning fluid nozzles directed in the in advance region, but also includes reamers having nozzles configured to direct a fluid spray in any radial direction, including at an associated cone **28**.

[0020] Directing the fluid spray **34** at a shallow angle with respect to the cutting surface, the fluid spray **34** cleans the entire width (or radius) of the cutting surface **36**. For the purposes of discussion herein, a shallow angle includes angles of from about 3° up to about 20° with respect to the cutting surface. The fluid spray may be directed at any angle between about 3° and about 20° specifically including from about 5° up to about 15°, from about 5° up to about 10°, as well as from about 5° up to about 7°. Removing the cuttings from the cutting surface **36** enables the cones **28** with its respective elements **30** to fully engage the cutting surface **36** without interference from previous cuttings or other debris. This reduces the chances for the cuttings to be redrilled by an adjacent cutter cone **28**. Fluid discharged from the nozzles **32** may be redirected up the annulus between the drill string and wellbore for recycling and removing the cuttings and other debris.

[0021] A side view of a fluid spray **34** interacting with the cutting surface **36** shown in a perspective view in FIG. 3. In this embodiment the nozzle **32** is shown secured within a portion of the shaft and vertically above the cutting surface **36**. Thus the resulting fluid spray **34** has a shallow downward angle, its center impinges close to the radius R middle. As can be seen, the fluid spray **34** contacts the cutting surface **36** along most of the radius R of the cutting surface **36**. The fluid spray axis AFS may range at an angle with respect to the housing axis A from about 60° to about 90° and all angular values therebetween. The fluid spray **34** is not limited to the shape illustrated, but may have a wider or more narrow fan width W.

[0022] An alternative embodiment of a reamer bit **20a** is illustrated in side view in FIG. 4. The rolling cutters provided on the reamer bit **20a** in FIG. 4 are cylindrical cutters **29**. The mounting elements for attaching the rolling cutters to the reamer bit **20a** comprise cradle mounts **33**. The cylindrical cutters **29** have impacts **31** formed on their outer circumference and rotate on a shaft (not shown) that extends through the cylindrical cutter **29** axis. The shaft ends are mounted in a cradle arm **35** that extends parallel to the shaft and over the cutter **29**. The cradle arm **35** depends at an angle downward from the cradle mount **33** lower end. The cradle mount’s **33** structure for attachment to the bit body **22a** is similar to the bit leg **26** structure for attachment to the bit body **22** of FIG. 1. Fluid sprays **34** are shown directed outward past the cutters **29** from the shaft **23**.

1. A reamer bit for downhole earth boring operations comprising:

- a reamer body having an axis;
- mounting elements depending from the body;
- a rolling cutter rotatably mounted to each mounting element; and
- a nozzle configured to form a fluid spray at an angle away from the body axis.

2. The reamer bit according to claim 1, wherein the cone includes cutting elements configured to cuttngly engage a wellbore cutting surface and wherein the fluid spray is directed to the cutting surface in advance of the cone cutting elements.

3. The reamer bit according to claim 1, wherein the fluid spray contacts the cutting surface at an angle of from about 5° up to about 20° with respect to the cutting surface.

4. The reamer bit according to claim 1, further comprising a drill shaft extending from the body lower end and a pilot bit affixed to the drill shaft terminal end.

5. The reamer bit according to claim 4, wherein the pilot bit comprises a bit selected from the list consisting of a roller cone bit and a drag bit.

6. The reamer bit according to claim 1, further comprising additional mounting elements having rolling cutters rotatably mounted to each mounting element, and additional nozzles configured to form a fluid spray associated with each rolling cutter.

7. The reamer bit according to claim 1 wherein the reamer bit is rotatable during reaming operations, and the nozzle is configured to direct a fluid spray in the direction of the reamer bit rotation.

8. The reamer bit according to claim 1, wherein the mounting element is selected from the list consisting of a bit leg and a cradle mount.

9. The reamer bit according to claim 1, wherein the rolling cutter is selected from the list consisting of a rolling cone cutter and a cylindrical cutter.

10. A pilot reamer apparatus for earth boring use comprising:

- a reamer body having an upper end and a lower end, and an axis extending through the upper and lower ends;
- a mounting element on the body outer periphery depending downwardly;
- a rolling cutter rotatably affixed to the mounting element formed for cutting engagement with a wellbore bottom cutting surface; and
- a nozzle configured to direct a fluid spray substantially tangential to the cutting surface.

11. The pilot reamer apparatus of claim 10 wherein the fluid spray axis contacts the cutting surface at an angle of from about 5° up to about 20° with respect to the cutting surface.

12. The pilot reamer apparatus of claim 10 wherein the nozzles are configured to direct fluid spray to the cutting surface in advance of the rolling cutters.

13. The pilot reamer apparatus according to claim 10, wherein the mounting element is selected from the list consisting of a bit leg and a cradle mount.

14. The pilot reamer apparatus according to claim 10, wherein the rolling cutter is selected from the list consisting of a rolling cone cutter and a cylindrical cutter.

15. A method of forming a wellbore comprising:
conducting earth boring operations with a reamer bit,
wherein the reamer bit comprises a body having an axis,

mounting elements depending from the body, rolling cutters rotatably affixed to the mounting elements having cutters formed in rows on their outer surface, and nozzles configured to direct a fluid spray on a cutting surface in advance of the rolling cutters that contacts the cutting surface at an angle of from about 5° up to about 20°;

urging a cleaning fluid spray from the nozzles thereby removing cuttings from the cutting surface in advance of the rolling cutters; and
receiving fluid discharged from the nozzles.

16. The method of claim 15, wherein the earth boring operations comprise rotating the reamer bit within a wellbore, the method further comprising directing the fluid spray in the direction of the reamer rotation.

17. The method of claim 15, wherein the reamer bit comprises additional mounting elements each having a rolling cutter, and a nozzle configured for directing a cleaning spray in advance of each nozzle.

18. The method of claim 15 wherein the reamer bit is engaged in earth boring operations in combination with a pilot bit.

19. The method of claim 15 wherein the mounting element is selected from the list consisting of a bit leg and a cradle mount.

20. The method of claim 15, wherein the rolling cutter is selected from the list consisting of a rolling cone cutter and a cylindrical cutter.

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